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National Centre for Sensor Research

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From Micro-Fluidic Valves to Polymer Cargo Boats Using Novel Functional Materials Based on Ionic Liquids

Fernando Benito López

(18th of May 2010)

OUTLINE

- **INTRODUCTION**
- **SPIROPYRAN: SWITCHABLE MOLECULE:**

–IONOGELS

- **MAGNETIC IONIC LIQUIDS AND IONOGELS**
- **SCHIZOPHRENIC MATERIALS BASED ON IONOGELS**

General Introduction

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Chemical sensors and biosensors depend on selective reactions at an active surface directly exposed to the sample.

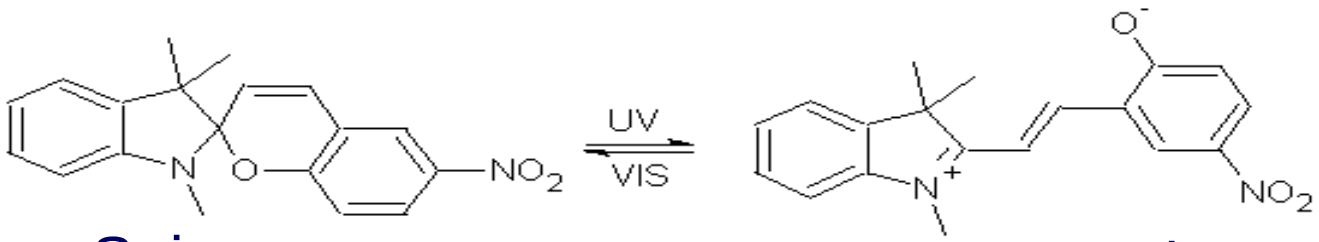
Active surfaces tend to change over time (fouling) causing drift and device failure

Adaptive Materials

Materials whose characteristics can be changed using an external stimulus

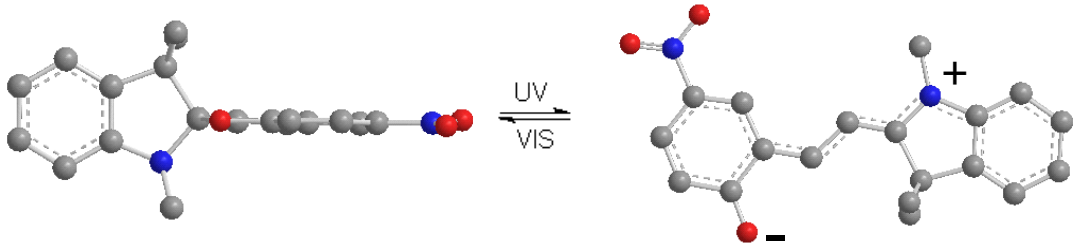
Possibility to reversibly switch a sensing surface between an ACTIVE mode (when measurement is needed) and a PASSIVE mode (when measurement is not needed)

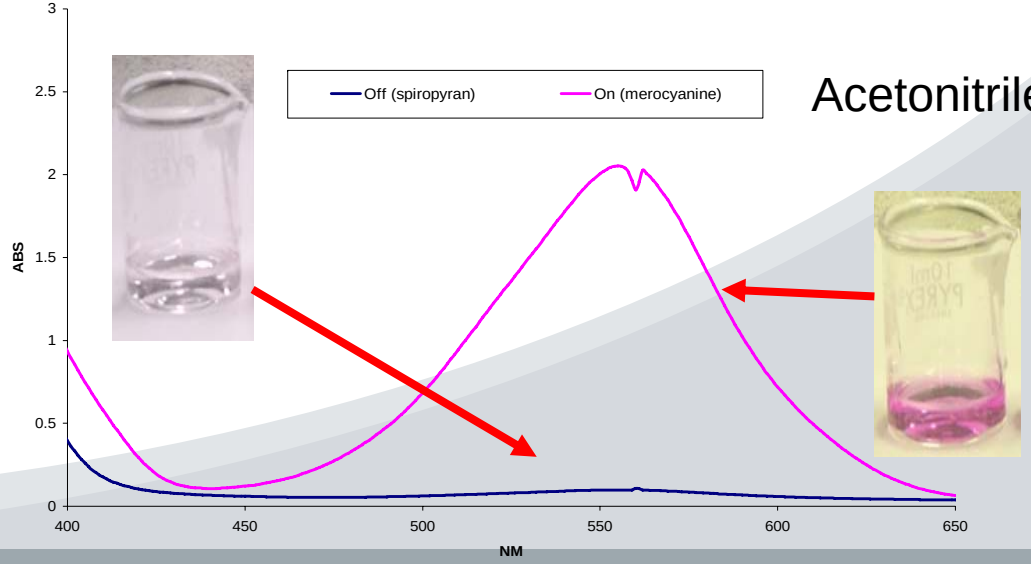
Molecular Switching



Spiropyran

Merocyanine

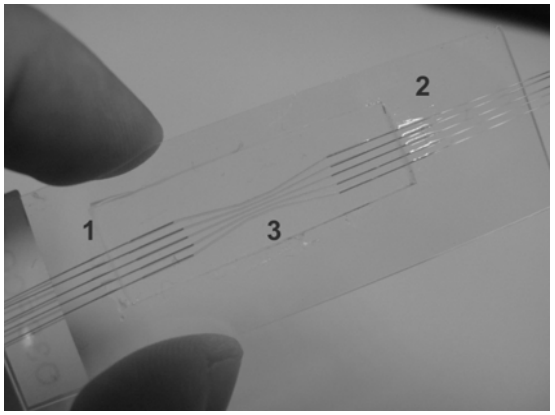


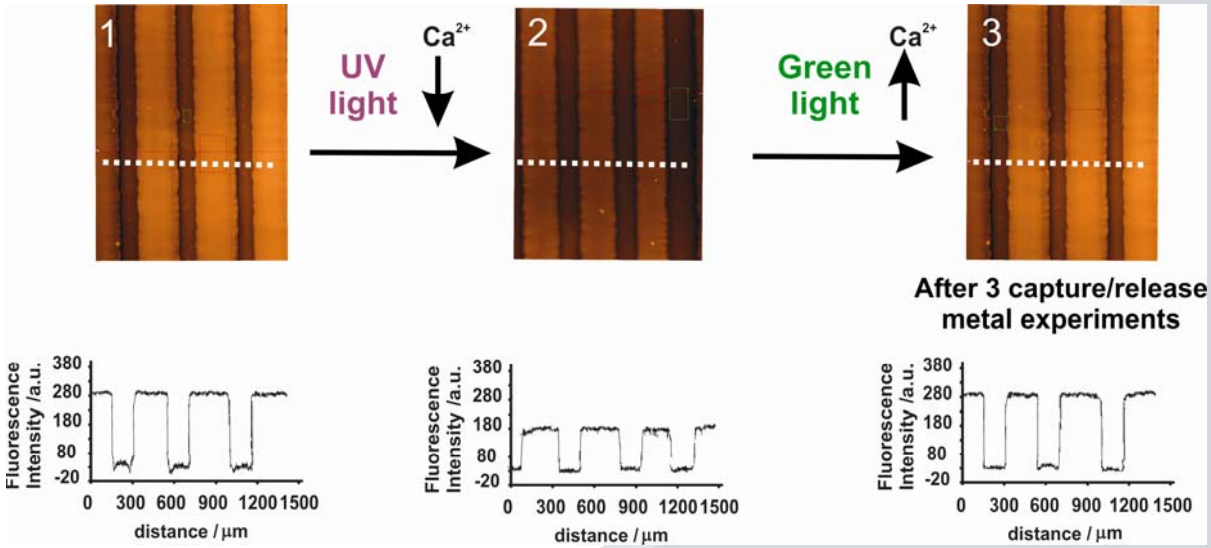


Acetonitrile

Spiropyran Functionalised PDMS Microchips

Spiropyran Modified Microchip Channels for Photonically Controlled Sensor Array Detection of Metal Ions





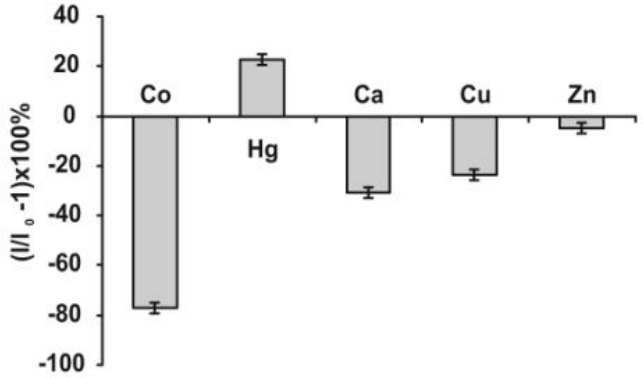


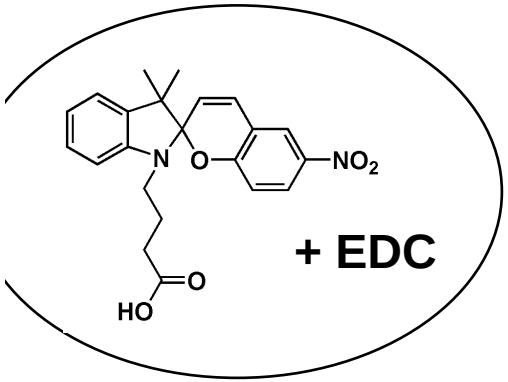
Photo-controlled uptake and release of metal ions.

The system is reversible through multiple cycles.

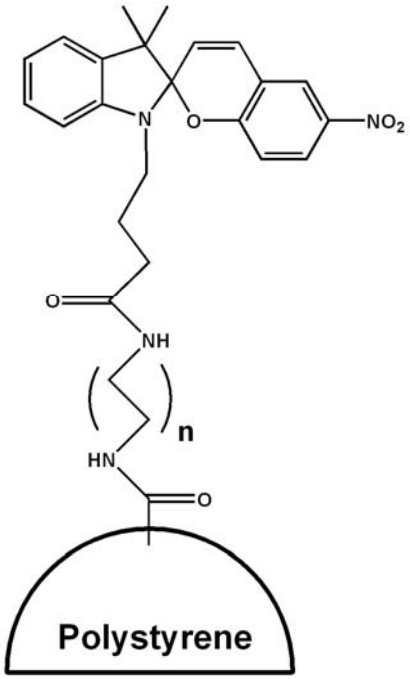
The platform is inexpensive; simple equipment.

F. Benito-Lopez, S. Scarmagnani, et al. Sens. Actuators B, 2009, 140, 295–303.

Spiropyran Beads Functionalisation

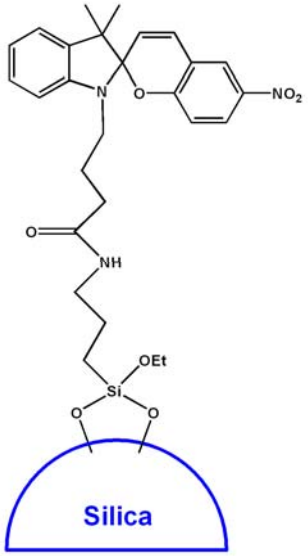


Polystyrene

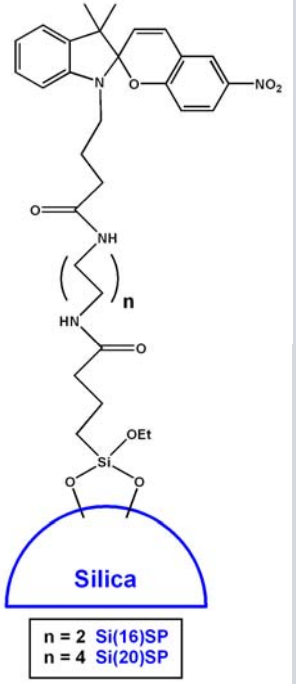


n = 2 PS(11)SP
n = 4 PS(15)SP

Silica

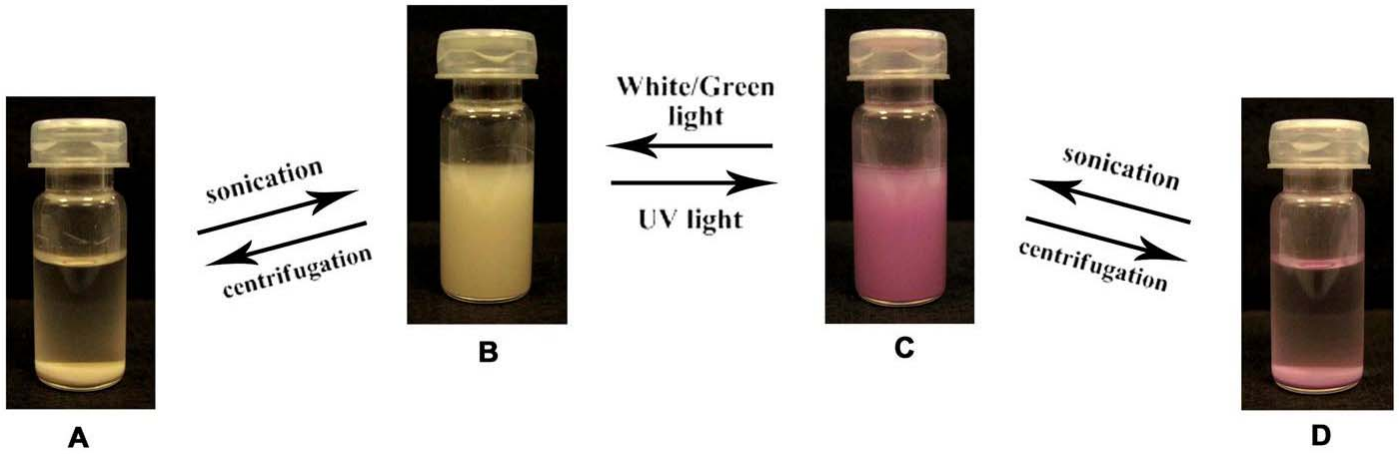


Si(10)SP



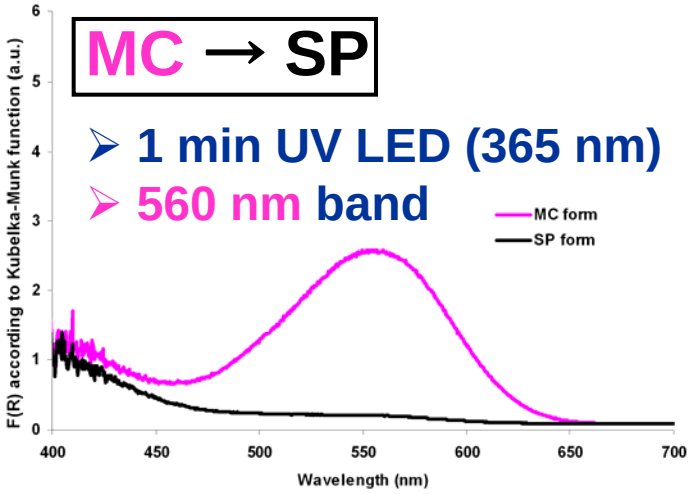
n = 2 Si(16)SP
n = 4 Si(20)SP

Spiropyran functionalised Polystyrene beads



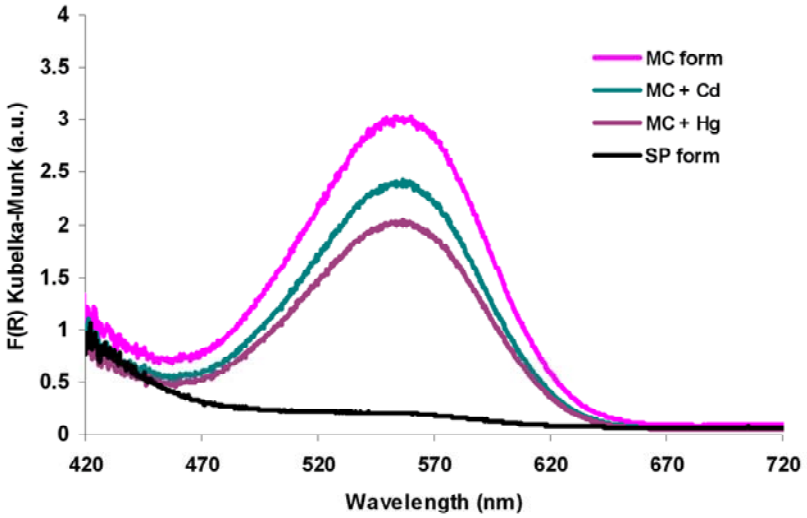
MC → SP

- 1 min UV LED (365 nm)
- 560 nm band



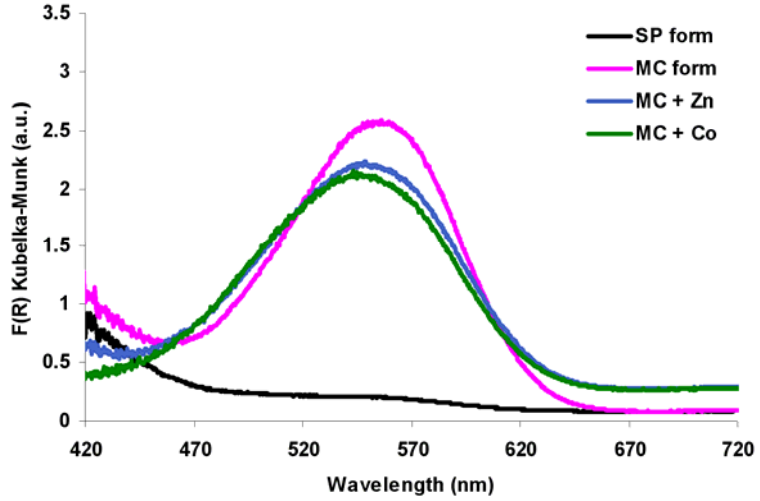
S. Scarmagnani, Z. Walsh, F. Benito-Lopez, et al. e-J. Surf. Sci. Nanotech., 2009, 7, 649-652.

Spiropyran functionalised Polystyrene beads

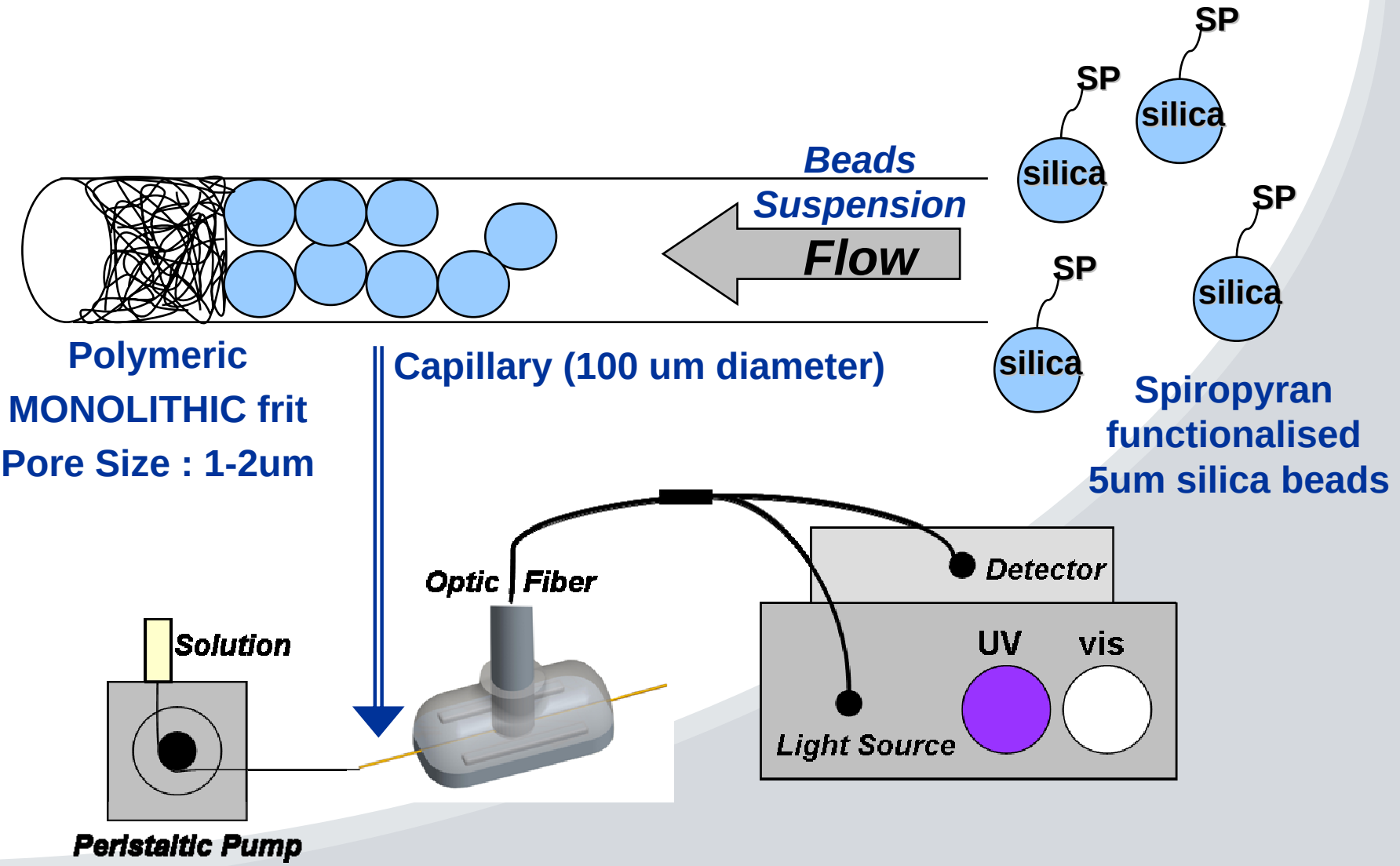


Cd^{2+} and Hg^{2+}
No spectral shift

Zn^{2+} and Co^{2+}
Small MC λ_{max} shift towards the blue region of the spectra

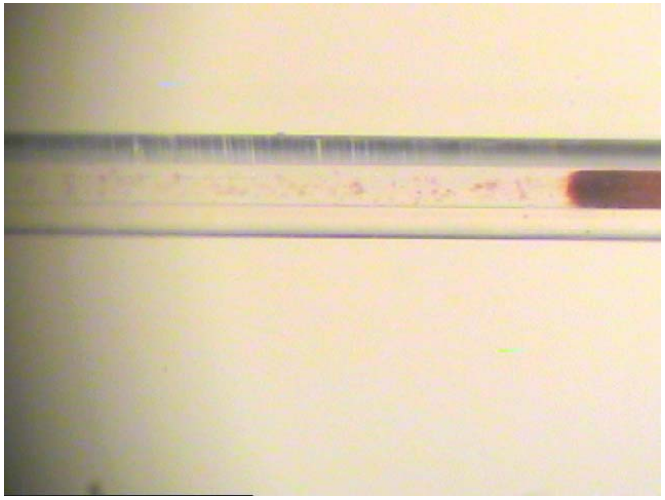


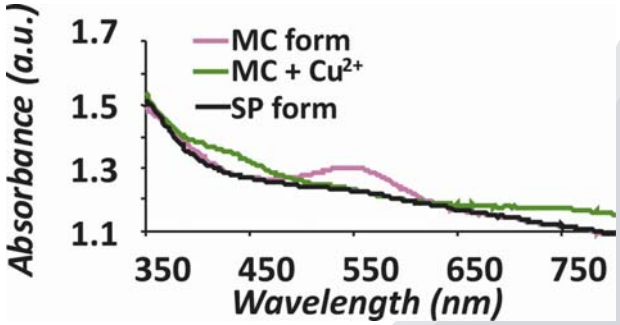
Capillary Packing and Reflectance Measurements

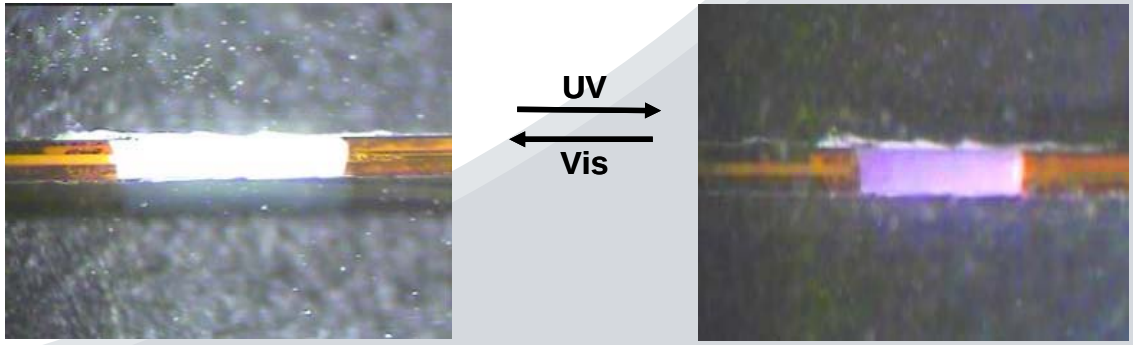


Spiropyran Functionalised Microbeads Chips

Photoswitchable Stationary Phase Based on Packed Spiropyran Functionalized Silica and Polystyrene Microbeads





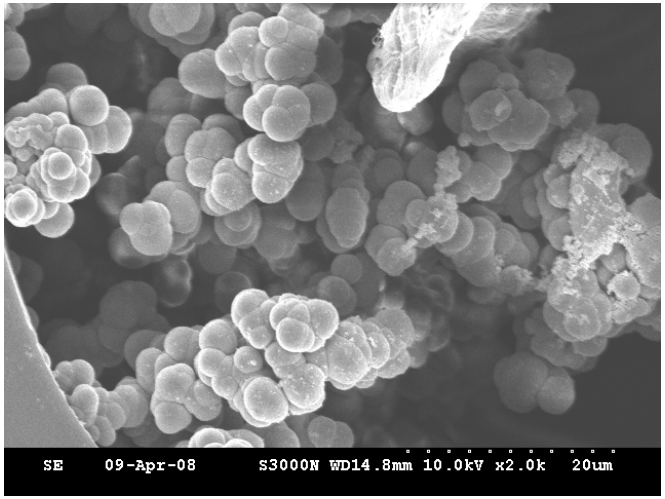


Polystyrene beads packed in a 360μm PDMS channel chip

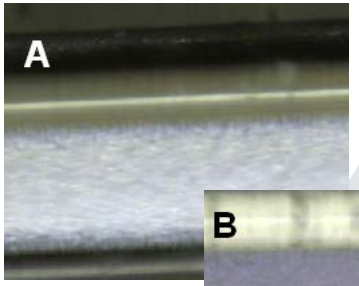
R. Byrne, S. Scarmagnani, F. Benito-Lopez, et al. Irish Chem. News -Nanotechnology edition, 2009, Jan, 26-28.

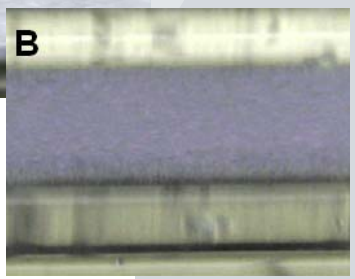
Spiropyran Functionalised Monolith chips

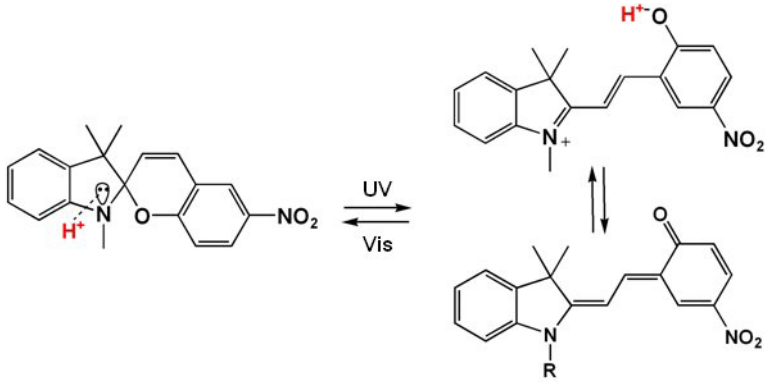
50% EOF decrease under White Light exposure

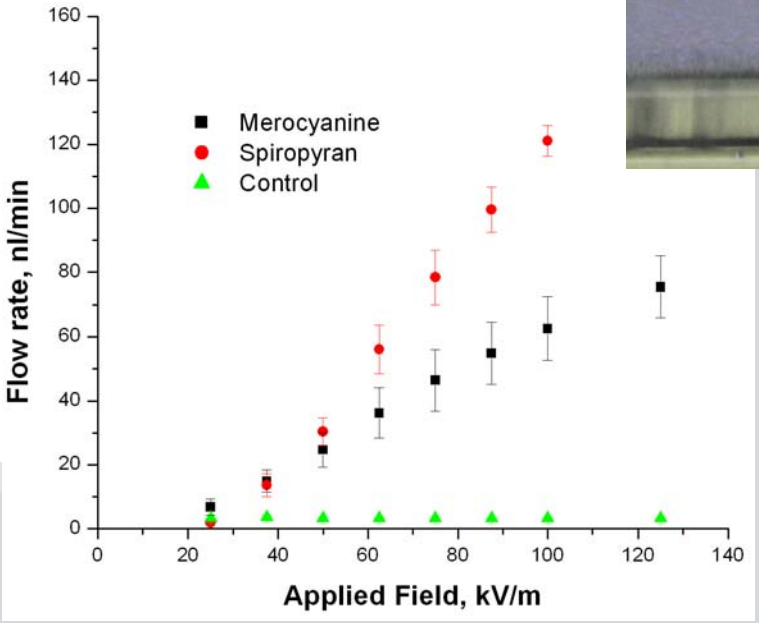


Monoliths:
spiropyran (A), colourless
merocyanine (B), blue









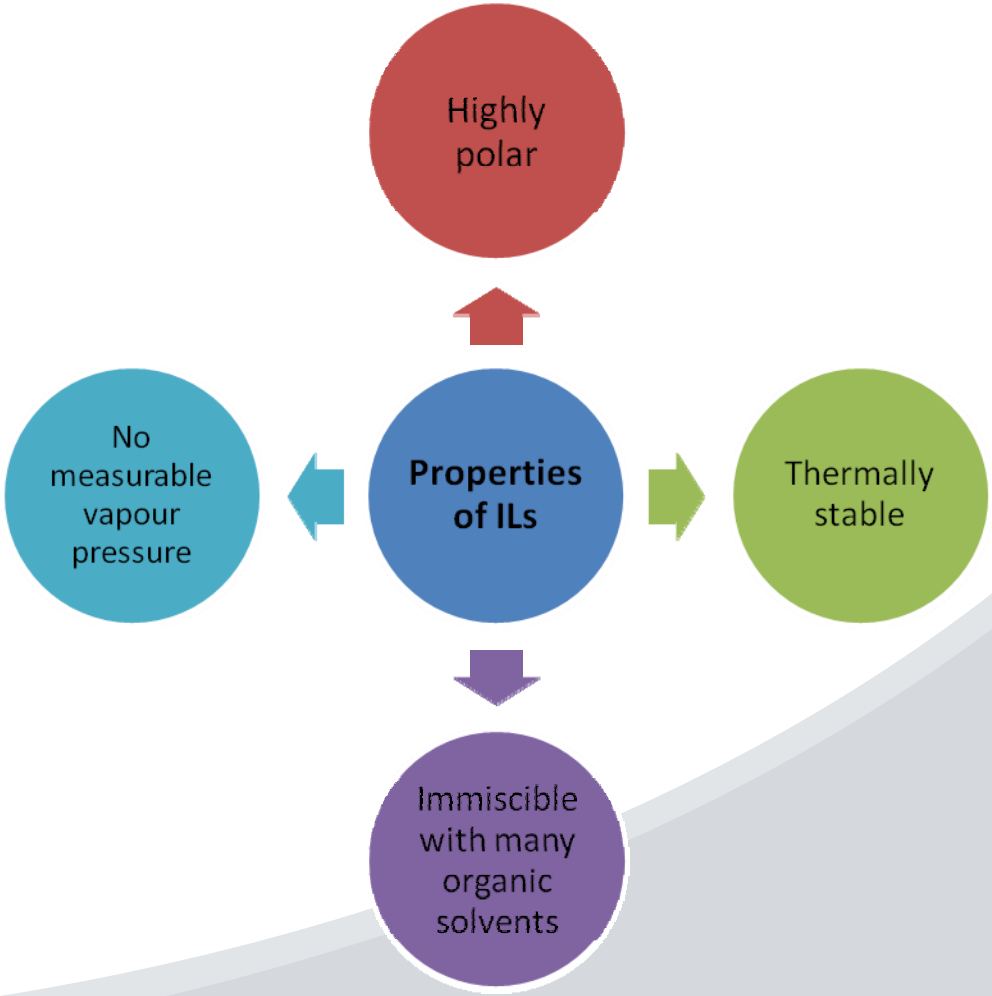
Z. Walsh, S. Scarmagnani, F. Benito-Lopez, et al. Sens. Actuators B., 2009. doi:10.1016/j.snb.2010.04.048.

IONIC LIQUIDS

- *The green chemistry movement!*
- *ILs are low melting point salts (<100 °C) that represent a new class of non-aqueous but polar solvents.*
- *Composed of ions: cations and anions.*
- *'Designer solvents' as their properties can be adjusted to suit the requirements of a particular process.*
- *The number of papers published in 1995 was approximately 20 and rose to 2,500 in 2006.*

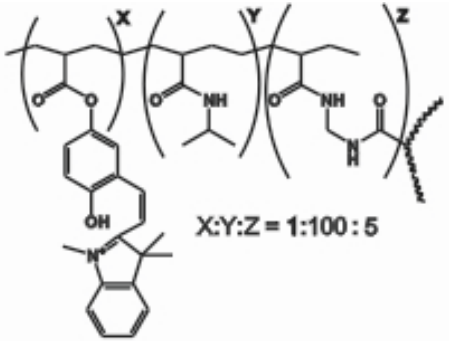
R. Byrne, F. Benito-Lopez, D. Diamond, Mater. Today, 2010, Submitted.

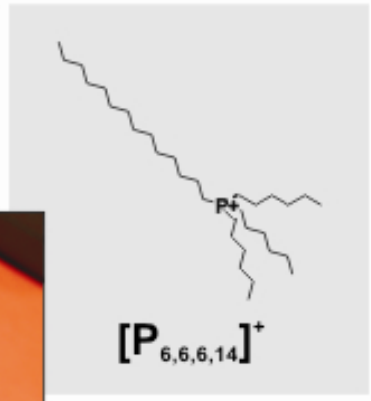
IONIC LIQUIDS

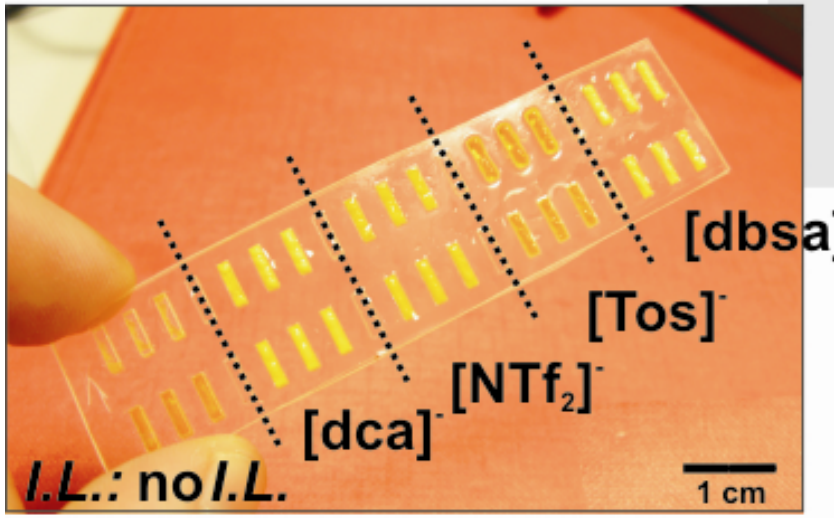


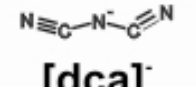
Photoresponsive ionogels as microvalves

When impregnating photoresponsive gels with ILs it is possible to tune the characteristics of photoresponsive gels (acid/ base character, viscosity etc.) by simply changing the IL.

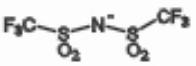






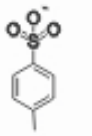


[dca]-

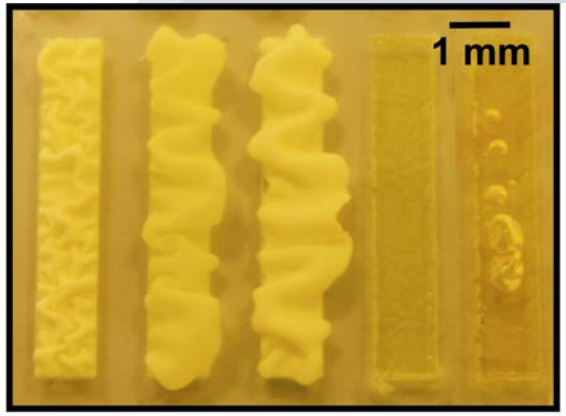


$[NTf_2]^-$

[dbsa]-



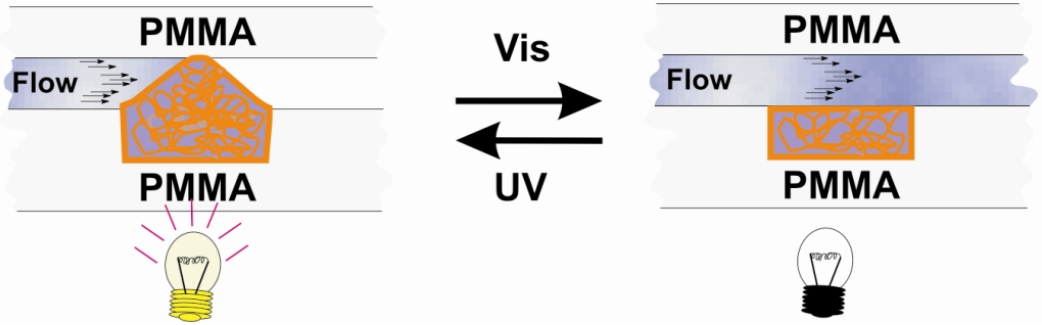
[Tos]-

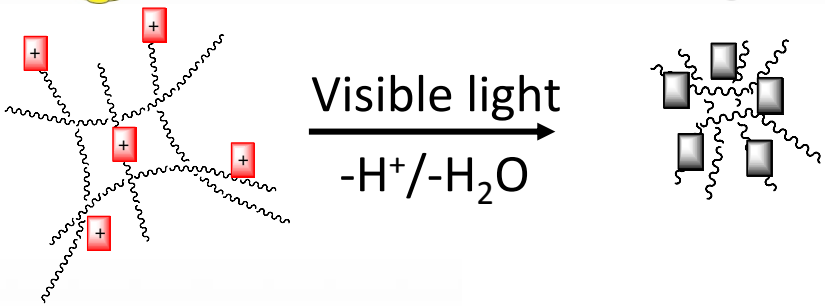


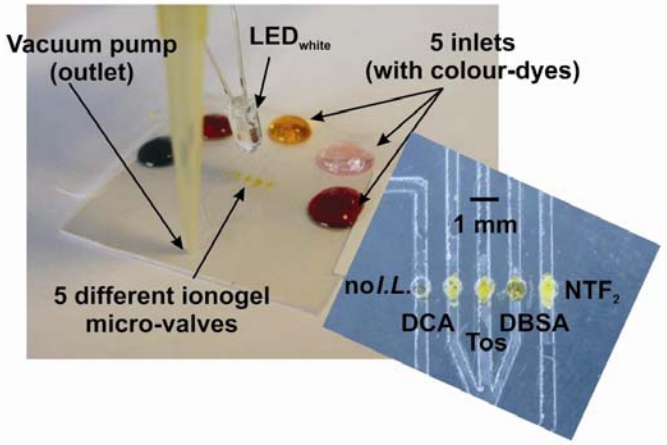
[dbsa]- $[NTf_2]^-$ [dca]- [Tos]- no *I.L.*

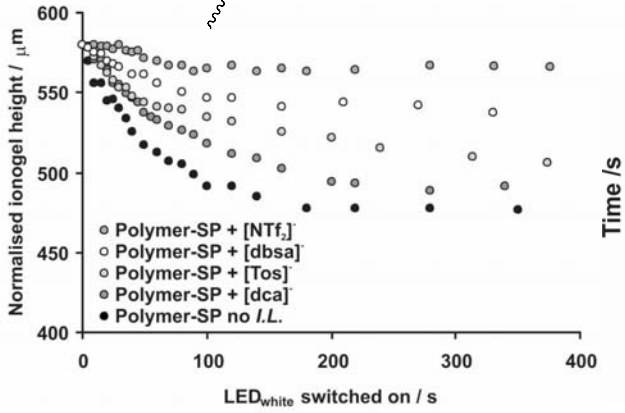
R. Byrne, C. Ventura, F. Benito-Lopez, et al. Biosens. Bioelectron. 2010, Submitted.

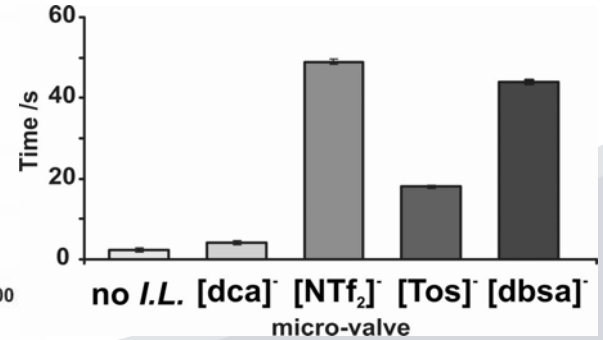
Photoresponsive ionogels as microvalves

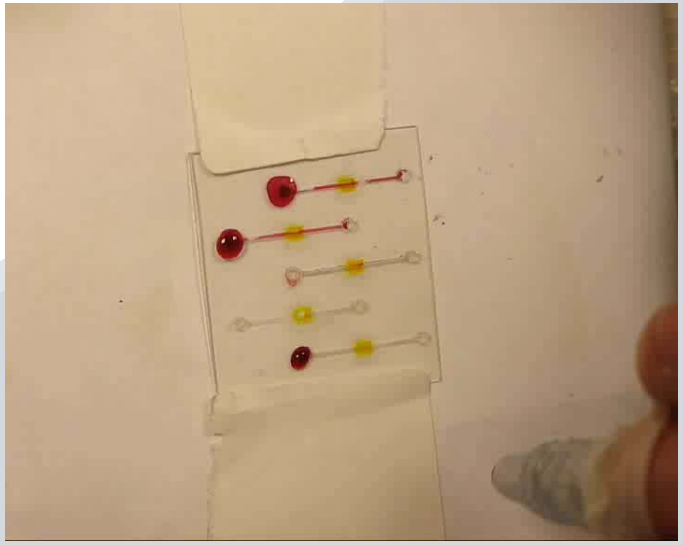












F. Benito-Lopez, R. Byrne et al. Lab Chip. 10, 2, 2009, 195-201.

Schizophrenic Materials

IONOGEL DINAMICS

Shape memory ionogels

RIBBONS H_2O **EtOH**

F. Benito-Lopez, R. Byrne, et al. ECS Transactions, 19, 6, pp. 199-210.

Schizophrenic Materials

IONOGEL DINAMICS

Shape memory ionogels

RIBBONS

H_2O

Schizophrenic Materials

IONOGEL DINAMICS

Shape memory ionogels

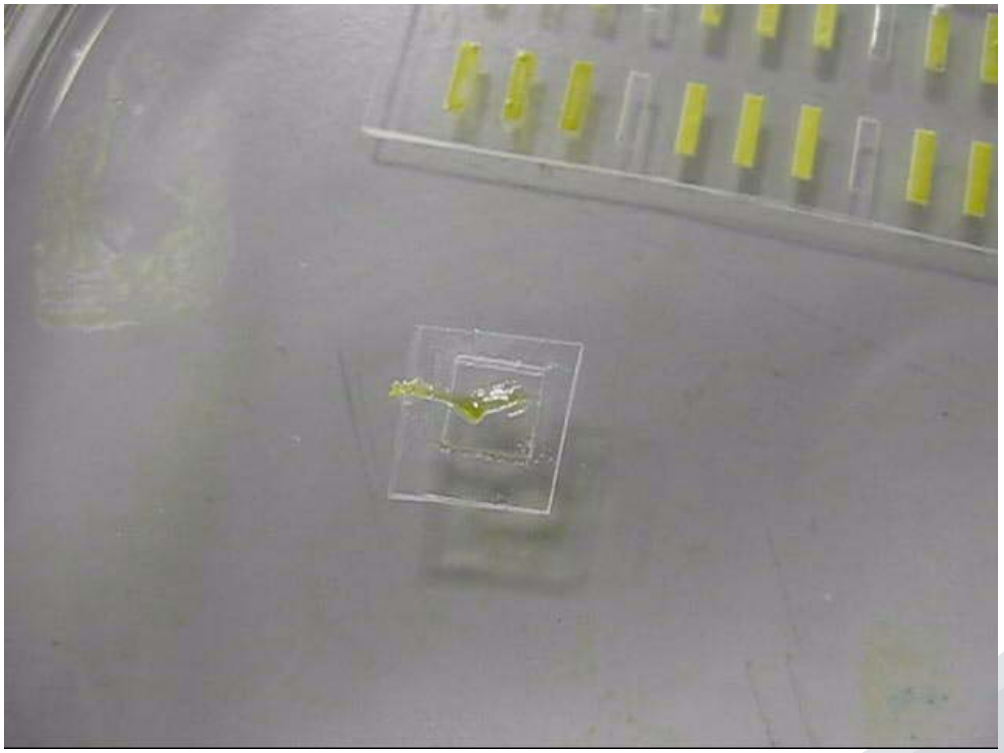
H_2O

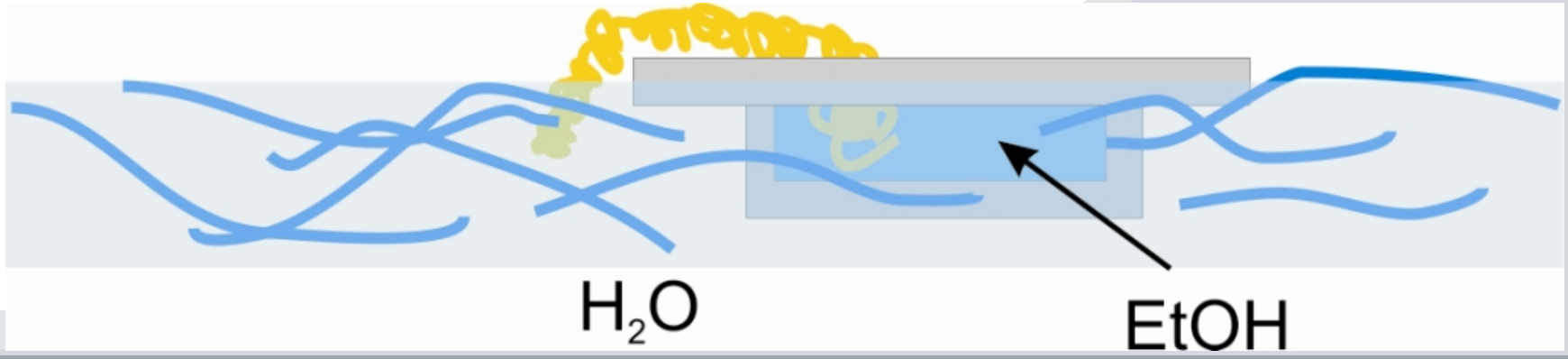
HEARTBEAT

Schizophrenic Materials

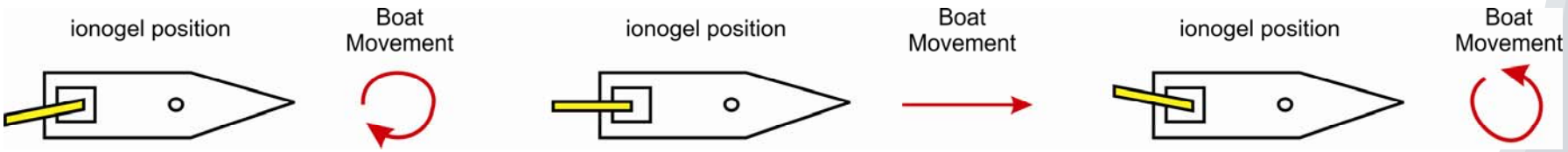
H_2O

Schizophrenic Materials





Schizophrenic Materials



Small boats

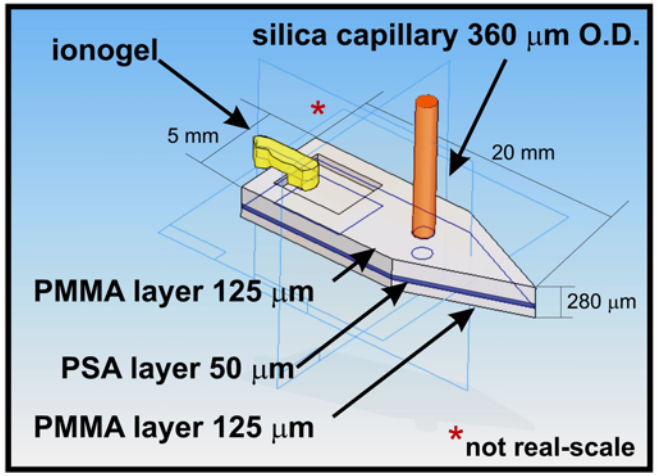
big boats

V: 50 mm s^{-1}
Low control

V: 35 mm s^{-1}
High control

R. Byrne, F. Benito-Lopez, et al. Proceedings of the 9th Nanotechnology Conference:IEEE NANO, 2009, 166-170.

Schizophrenic Materials



V: 10 mm s^{-1}

Higher control

Acknowledgements

Dr. Silvia Scarmagnani

Dr. Robert Byrne

Prof. Dermot Diamond

Science Foundation Ireland under grant 07/CE/I1147

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QUESTIONS???